31

Stauffer Chemical Company

Westport, Connecticut 06881 / Tel. (203) 222-3000 / Cable "Staufchem"

ORIGINAL (Red)

October 4, 1984

Mr. Richard L. Zambito
Regional Project Officer
U.S. Environmental Protection Agency
Region III
6th and Walnut Streets
Philadelphia, PA 19106

Re: Progress Report
Feasibility Study
Delaware City PVC Site

Dear Mr. Zambito:

Enclosed please find the first scheduled progress report for the subject project. This report is being submitted in accordance with the Administrative Order on Consent of May 23, 1984, between Formosa Plastics Corporation, Stauffer Chemical Company, the State of Delaware and U.S. Environmental Protection Agency. The report was prepared jointly by Malcolm Pirnie, Inc. and Roux Associates, Inc. for Stauffer and Formosa and summarizes the work conducted in Items 1.0 through 3.0 of the Remedial Action Feasibility Study Outline, Attachment C of the Order referenced above.

In addition, attached to this letter is a tabulation of the analytical results, Table I, for samples collected 8/21 through 8/23/84. Review of Table I will show that at three wells, OW-10, OW-11 and OW-17, compounds other than EDC, VCM and TCE were detected.

In an analysis conducted on samples collected from OW-15 in April, 1983 an unidentified compound was detected and reported to the Agency April 21, 1983, as a nonpriority pollutant. Comparison of the GC data of the previous detection to the current detections in OW-10, OW-15 (17,000 ppb) and OW-17 shows a similar GC pattern leading Stauffer to suspect that these are the same compound. The compound has a GC retention time which indicates it to be more volatile than VCM.

Should you have any questions regarding this letter or the attached material, please do not hesitate to contact me. I look forward to meeting with you shortly at the scheduled review meeting.

Sincerely,

Bruce S. McClellan

Bruce S. McClellan

AR300177

BSM:dm
Attachment

cc: R. Boyer (FPC)
J. DeMartinis (Roux)
M. Mann (Malcolm Pirnie, Inc.)
S. Young (State of Delaware)

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TABLE 1

***Analysis of Delaware City Plant Well Water For Vinyl Chloride Monomer (VCM), 1,2-Dichloroethane (EDC), and Trichloroethylene (TCE)

Samples collected 8/21 - 8/23/84
Samples analyzed 8/24 - 8/31/84

Sample	VCM	EDC	TCE	Other Compounds
	Concentration (ppb)			
OW- 3	*ND	**Det	ND	ND
OW- 5	310	1600	13	ND
OW-10	Det	230	4	One at 100 ppb
OW-11	250	40	4	Three at 17,000, 50, and 25 ppb
OW-13	ND	ND	4	ND
OW-14	ND	ND	9	ND
OW-16	ND	ND	Det	ND
OW-17	210	3400	15	One at 3,400 ppb
OW-17A	ND	Det	Det	ND
°OW-18	ND	ND	ND	ND
°OW-19	ND	ND	ND	ND
OW-22	ND	ND	ND	ND
°OW-28	ND	ND	15	ND
°OW-29	ND	ND	ND	ND
OW-30	50	1100	Det	ND
OW-31	ND	ND	7	ND
°OW-32	ND	ND	ND	ND
OW-33	ND	ND	ND	ND
Lower Limit of Detection	1	1	1	10
QA spikes at 10 ppb (Average % recovery from duplicate analysis)	105%	93%	94%	

° - samples split with EPA's contractor, NUS.
*ND - Not detected.
**Det- Detected below the lower limit of quantitation = 3 ppb.
*** - Analysis by purge and trap gas chromatography with flame ionization detection.

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CONSULTING GROUND-WATER GEOLOGISTS
ROUX ASSOCIATES INC

ROUX

50 NORTH NEW YORK AVENUE
PO BOX 266, HUNTINGTON, NEW YORK 11743 516 673-4921
PO BOX 190, FAIRFIELD, CONNECTICUT 06530 203 254-1439

September 27, 1984

Mr. Bruce McClellan
Stauffer Chemical Company
Nyala Farm Road
Westport, CT 06881

Dear Mr. McClellan:

Enclosed please find a formal report summarizing the work conducted in 1.0 through 3.0 of the Remedial Action Feasibility Study for the Delaware City Site. This report has been prepared jointly by Malcolm Pirnie, Inc. and Roux Associates. Included are a summary of the site conditions, statement of response objectives and criteria evaluation process, and remedial options selected for further evaluation.

Should you have any questions on any of the above, please do not hesitate to contact us.

Sincerely yours,
Malcolm Pirnie, Inc.

Michael J. Mann

Michael J. Mann
Manager, Hazardous Waste

Roux Associates Inc.

James DeMartinis

James DeMartinis
Senior Hydrogeologist

cc. Mr. Robert Boyer, FPC
Mr. Mel Beers, SCC

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1.0 PROJECT UPDATE

A finding of EDC and VCM in a domestic supply well on Stauffer Chemical Company property on April 20, 1982 prompted an investigation of the source of these compounds, their impact on the Columbia aquifer, and their potential impact on other nearby wells. A detailed hydrogeologic investigation including monitoring well installation, a resistivity survey and well-sampling was conducted and results are described in the Roux Associates, Inc. report dated 2/4/83. The source(s) of the EDC and VCM to the ground water and the limits of EDC/VCM in the Columbia aquifer were identified and are specifically designated in the subsequent Administrative Order of Consent signed by Stauffer Chemical Company, Formosa Plastics Corporation Delaware, DNREC and EPA on May 23, 1984.

1.1 Additional Monitoring Well Installation

After the submittal of the 2/4/83 report, EDC and VCM were detected in the Foraker Getty and Stapleford Chevrolet wells south of the mapped plume area. Two monitoring wells, OW-30 and OW-31, were installed to determine if these occurrences were related to the plume.

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At this time two additional wells, OW-32 and OW-33, were also installed to better define the northern terminus of the plume. The analysis of ground-water samples from the four wells did not show EDC or VCM. It was concluded that the EDC/VCM found in the two domestic wells was a slug which became detached from the main plume, prior to discharge into Dragon Run.

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1.2 Existing Site Conditions

A water table map compiled from data collected on April 10, 1984 is shown on Figure 1. Stauffer has routinely collected water-level data on a regular basis through 1983-1984 (Table 1). Figure 1 is a representative water table map. The configuration of the water table has not varied significantly during this period of time.

Figure 1 shows a mound in the water table under the western portion of the PVC plant property. The highest water level in this mound was recorded at OW-11, east of the identified source(s). This level is probably caused by water losses at the plant (fire water ponds, cooling water towers) upgradient of the identified source area. Ground water flows from the area of this mound to the northwest, west and southwest. Ground water containing EDC and VCM is flowing west from the area of the PVC

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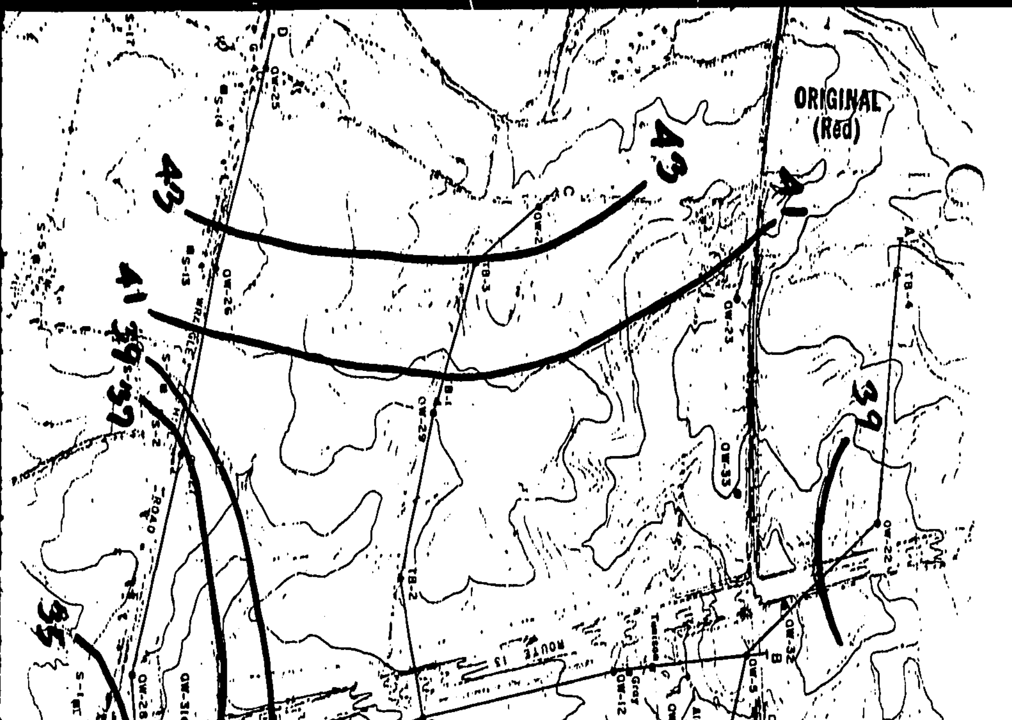

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TABLE I WATER LEVELS - DELAWARE CITY

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WELL #	6/11/83	6/30/83	7/7/83	7/21/83	8/3/83	9/16/83	10/17/83	11/22/83	12/20/83	2/[illegible]/84	4/10/84
OW-1	41.09	41.41	41.66	42.00	41.83	41.00	40.60	43.00	38.75	40.33	[illegible]
OW-1A	39.05	42.30	42.18	41.60	42.18	41.63	41.13	41.30	42.10	42.58	42.40
OW-2	40.75	41.34	44.92	41.92	41.67	41.00	40.48	39.59	39.50	40.34	41.85
OW-3	40.58	40.75	40.91	41.16	40.91	40.16	39.58	39.83	38.83	39.66	40.58
OW-4	41.92	42.50	42.59	43.09	42.92	40.35	41.42	40.78	40.67	41.59	42.59
OW-5	40.67	40.50	40.67	40.92	40.67	39.67	39.26	38.53	38.67	39.34	40.34
OW-6	45.42	45.26	45.40	45.34	44.34	41.67	43.34	43.85	44.34	45.59	45.84
OW-7	45.17	45.42	45.84	45.75	45.00	44.40	43.84	43.42	44.26	46.25	46.17
OW-8	45.08	45.25	45.5	45.75	45.33	44.25	43.75	43.25	44.16	45.33	45.91
OW-9	44.60	44.92	45.00	45.17	44.92	43.92	43.59	42.92	43.75	44.50	45.84
OW-10	44.26	44.92	45.00	45.00	44.92	44.00	47.92	47.25	43.25	44.00	45.58
OW-11	47.00	47.16	47.08	46.83	46.33	45.41	45.00	46.08	45.83	47.10	47.33
OW-12	40.42	41.00	41.09	40.58	41.83	40.75	40.00	39.33	39.83	[illegible]	40.92
OW-13	44.50	42.00	44.92	44.92	44.75	43.75	43.34	44.05	43.09	44.09	41.5
OW-14	41.33	40.91	42.08	42.33	42.16	41.50	40.59	39.91	39.91	40.91	42.00
OW-15	40.17	40.5	40.42	40.67	40.85	41.17	39.5	39.92	38.92	39.50	40.67
OW-16	37.75	37.75	37.76	37.97	37.07	37.00	37.75	36.05	36.83	37.17	38.[illegible]
OW-17	40.83	41.66	41.75	42.08	41.91	41.00	40.58	39.83	39.75	40.50	41.83
OW-17A	40.46	41.54	41.71	41.96	41.79	41.13	40.46	39.79	39.63	40.39	41.38
OW-18	32.50	31.33	31.00	30.00	29.5	29.16	30.41	32.83	32.58	32.33	32.25
OW-19	45.50	45.00	44.75	45.25	43.83	42.08	41.16	40.58	41.25	24.50	44.50
OW-20	38.08	38.09	37.83	37.83	37.25	36.58	36.08	35.75	48.41	54.00	37.66
OW-21	38.58	38.50	38.58	38.50	38.50	37.58	37.25	36.91	37.41	37.83	38.66
OW-22	37.58	37.66	37.66	37.50	37.25	36.33	35.91	35.58	36.58	36.58	37.91
OW-23	39.92	40.17	39.84	39.67	39.25	38.34	38.00	37.84	46.17	39.25	40.42
OW-24	42.25	42.67	42.59	42.50	42.17	41.09	40.59	40.34	41.09	41.75	43.34
OW-25	43.75	44.50	44.58	44.91	44.58	43.41	42.33	41.33	41.50	42.41	44.33
OW-26	41.59	42.34	42.50	42.92	42.75	41.75	40.92	39.92	40.09	41.34	42.75
OW-27	36.67	36.17	37.25	37.50	37.42	36.50	36.25	35.67	36.[illegible]	36.42	37.25
OW-28	35.58	35.59	35.66	35.66	35.33	34.66	34.50	34.08	34.58	34.83	35.75
OW-29	40.09	40.66	40.66	41.25	41.16	40.33	40.00	39.16	39.16	39.83	40.83
OW-30	35.42	35.42	35.50	35.50	35.25	34.83	34.58	34.50	34.75	35.00	35.67
OW-31	36.50	36.33	36.25	36.25	36.08	35.58	35.33	35.08	35.50	35.67	36.67
OW-32	40.05	40.97	40.22	40.18	40.05	44.05	38.55	37.97	38.55	38.80	39.97
OW-33	39.92	40.33	40.25	40.25	40.17	39.25	38.67	38.17	39.00	39.25	40.42

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impoundments. Ground water flowing to the northwest toward OW-5 turns in a northerly direction (roughly parallel to Route 13) and flows toward Red Lion Creek. Ground water flowing from the PVC plant toward OW-16 turns in a southerly direction and flows to Dragon Run.

The sediments are more permeable and the gradient is steeper to the south especially near the tributary to Dragon Run. This is indicating that a greater amount of ground water is discharging into Dragon Run.

Figure 2 shows the EDC/VCM plume as taken from Roux Associates' report "Hydrogeology and Ground-water Conditions" dated February 4, 1983. Values of EDC and VCM from the most recent round of sampling (August 1984) are plotted on this figure to compare with the limits of the plume identified in the Roux Associates report and in the Administrative Order of Consent dated May 23, 1984. Comparison of this figure, subsequent sampling results and the latest results indicate:

(1) The ground-water sample from OW-30 shows 1,100 ppb EDC and 50 ppb VCM. This finding is consistent with ground-water flow directions mapped over the past year. This well showed no EDC or VCM the first (and

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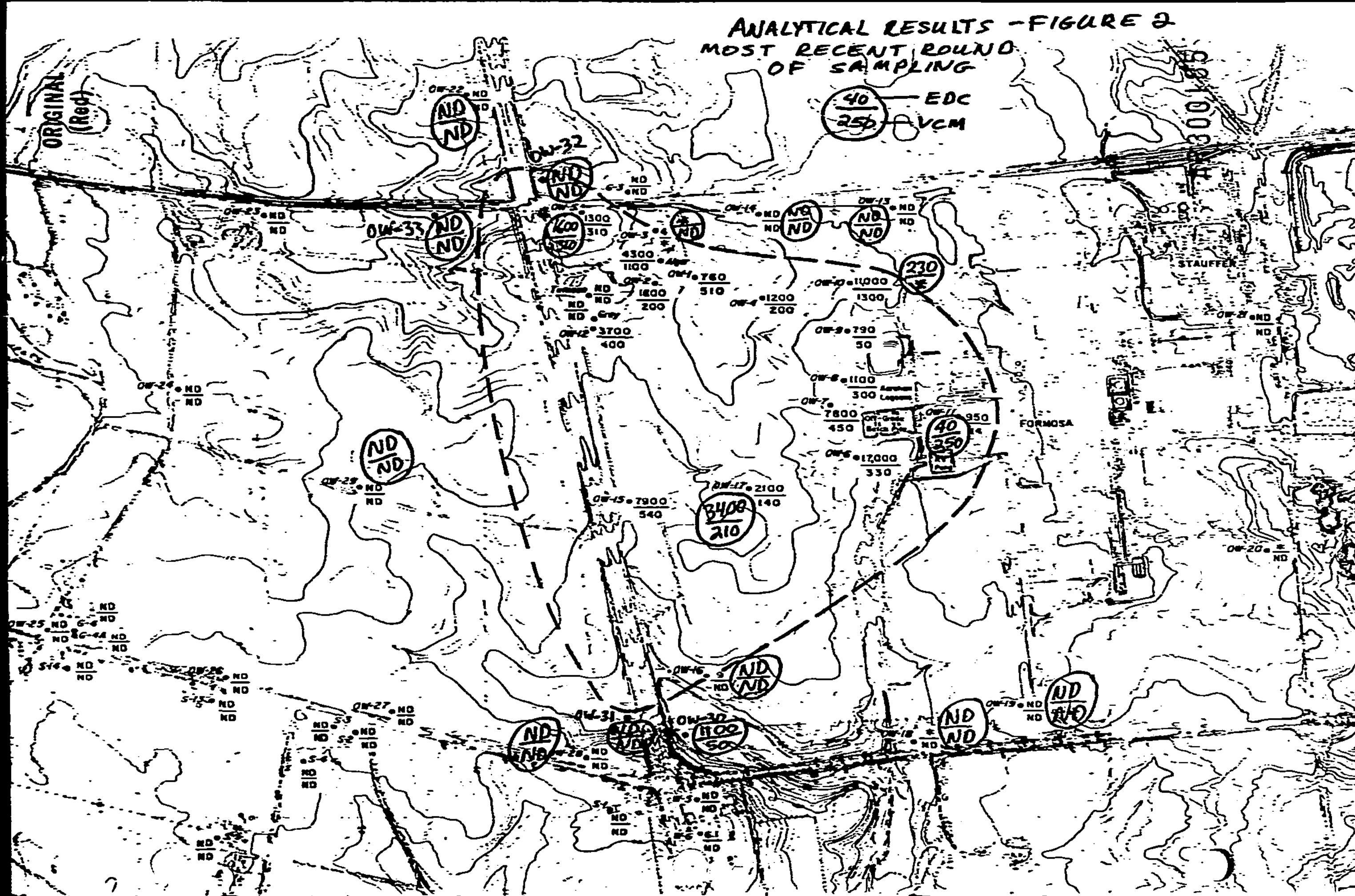
ANALYTICAL RESULTS - FIGURE 2
MOST RECENT ROUND OF SAMPLING



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only) time it was sampled. This finding as well as previous findings in the Foraker Getty and Stapleford wells appear to represent a slug which became detached from the plume prior to discharging into Dragon Run.

(2) It appears that the plume has stabilized in the northerly direction. Despite findings of EDC and VCM in OW-5 from the inception of the project, OW-33, OW-32 and OW-22 have never shown EDC or VCM. Sediments in the Columbia aquifer in this area are significantly less permeable than those to the south and the gradient is flatter (Figure 1).

(3) No wells west of Route 13 have ever shown EDC or VCM (OW-33, OW-29, OW-31, OW-28 in the most sampling - all others in previous samplings).

1.3 Determination of Seepage Velocity from the Columbia Aquifer through the Merchantville Aquitard into the Magothy.

During the drilling of OW-31, OW-32 and OW-33, undisturbed samples of the Merchantville Formation were collected and analyzed for permeability. The three samples had permeabilities of 8.3×10^{-8}, 6.8×10^{-7} and 1.8×10^{-8} cm/sec, respectively.

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The Darcy Equation can be used to calculate the average seepage velocity of a mass of water progressing through the pore spaces of the Merchantville as follows;

$$V_s = \frac{Ki}{n_e}$$

where V_s = seepage velocity

K = permeability of the Merchantville

i = hydraulic gradient under which seepage occurs

n_e = effective porosity of the Merchantville

K has been determined by laboratory analysis on undisturbed Mechantville samples and a value of 1×10^{-8} cm/sec will be substituted into the above equation.

The hydraulic gradient is the head difference between the Columbia and Magothy aquifers (h) divided by the thickness of the Merchantville (l). The head difference is estimated at 25 feet as the piezometric surface of the Magothy is estimated at 15-20 feet above mean sea level (Sundstrom and Pickett, 1971).[1] This is probably a high number. The thickness of the Merchantville is assumed to be 20 feet (based on test boring data) though it is probably thicker under most areas of the plume.

The effective porosity of the Merchantville is estimated at 30 percent or 0.30.

[1]The Availability of Ground Water in New Castle County

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Substituting these values into the above equation;

$$V_s = \frac{(10^{-8}\ \text{cm/sec})\ (1.25)}{0.30}$$

V_s = 4.2 x 10^{-8} cm/sec <u>or</u>

V_s = 1.3 cm/year

Since the thickness of the Merchantville is approximately 20 feet or 609.6 cm, it would take 469 years for ground water in the Columbia aquifer to penetrate the Merchantville and enter the Magothy.

1.4 Installation of 2" Diameter Observation Wells

During the week of August 13-17, 1984, eleven two-inch diameter observation wells were installed at the Delaware City Site by H.P. Drilling of National Park, N.J. These wells were drilled and installed in accordance with Attachment I of the Administrative Order of Consent under the supervision of a geologist from Roux Associates. Locations are shown on Figure 3 and construction details are given in Table 2.

One soil sample was collected from one piezometer boring at each pumping well location. A sieve analysis and a determination of organic carbon content is presently being run on each sample to help evaluate rate of migration of EDC/VCM in the aquifer.

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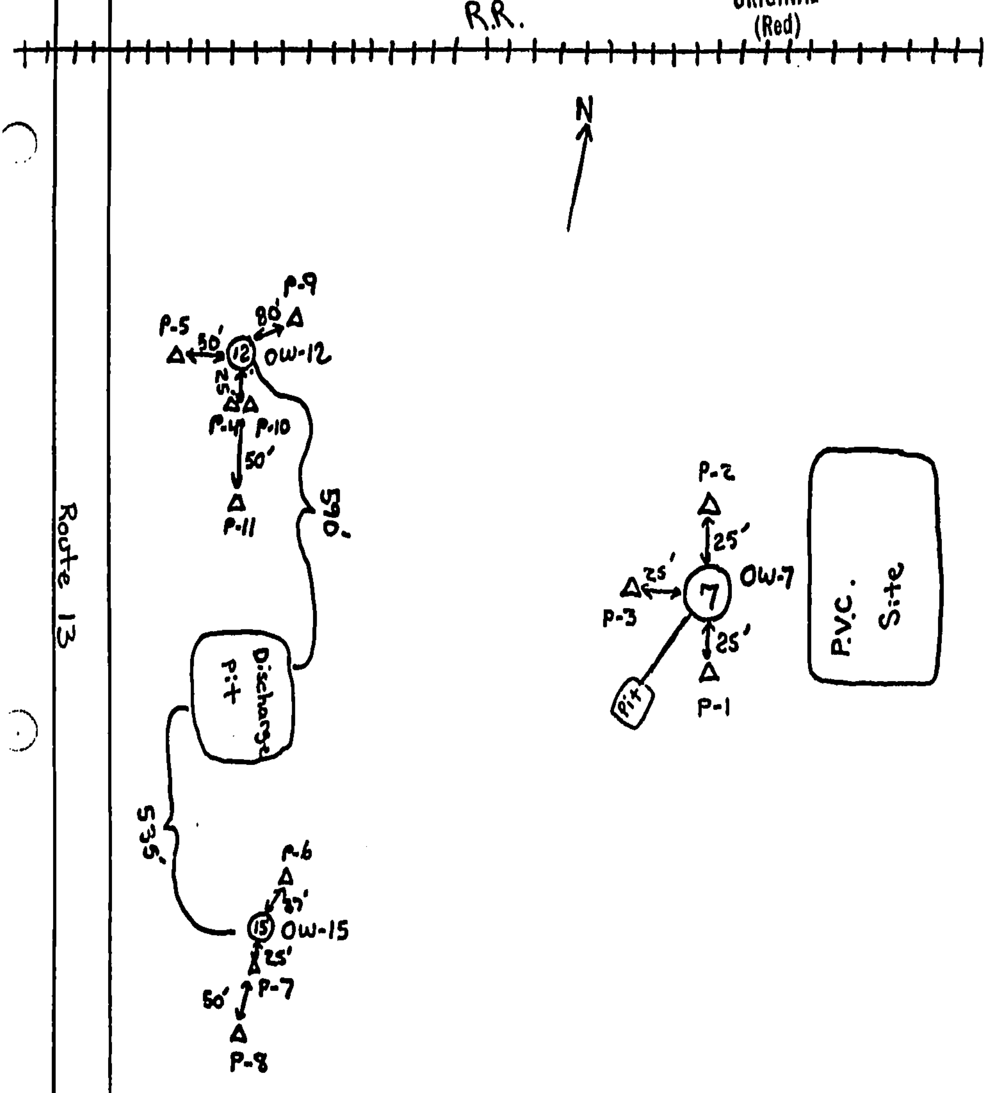

Figure 3

Sketch - Not to scale
Delaware City PVC Site

(12) Pumping Well - 4"

Δ Observation Well - 2"

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DELAWARE CITY, DELAWARE

WELL CONSTRUCTION DETAILS

TABLE 2

Well #	Bottom of Boring 1)	Screen Zone 1)	Stickup	Well Diameter (inches)
P-1	30'	15'-25'	2'	2
P-2	30.5	18.5'-28.5'	1.5'	2
P-3	30'	18.5'-28.5'	1.5'	2
P-4	32'	21.65'-31.65'	.35'	2
P-5	65'	54.5'-64.5'	2'	2
P-6	51'	37'-47'	3'	2
P-7	52.5'	38.2'-48.2'	1.8'	2
P-8	50'	37.2'-47.2'	2.8'	2
P-9	65'	53.25'-63.25'	1.75'	2
P-10	64'	53.2'-63.2'	1.8'	2
P-11	64'	53.2'-63.2'	1.8'	2

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At the completion of drilling all wells were developed by surging with air. This was done to remove any drilling fluids that might still be in the formation and to insure a good connection between the aquifer and the well screen.

1.5 Specific Capacity Testing

Selected monitoring wells, both inside and outside of the plume, were test pumped for fifteen minutes at 50, 30, and 10 gallons per minute respectively. Water levels were measured regularly prior to, during and after pumpage. It was determined that none of the wells tested could sustain 50 gpm over an extended period of time (greater than 15 minutes). Some wells could be pumped at 30 gpm but water levels would decline into the screen zone with time.

OW-12, OW-15 and OW-7 had specific capacities of 1.32, 2.01, and 1.42 gpm per foot of drawdown respectively. Other wells tested and their specific capacities are as follows: OW-1 (3.53), OW-2 (2.39), OW-6 (1.56), OW-8 (3.68), OW-9 (0.70), OW-10 (3.02), OW-11 (1.00), OW-16 (0.80), OW-17 (5.15), OW-28 (5.38) and OW-29 (7.52). This demonstrated that OW-12, OW-7, and OW-15 could be pumped at between 10 and 15 gpm for the long term pumping tests.

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1.6 Pre-Pump and Pump Tests

To determine aquifer hydraulic parameters necessary for design of any potential ground-water intercept system, the following pump test program was conducted according to Attachment 1 of the Administrative Order of Consent.

During the week of August 20, 1984 a pre-pump test was run on OW-12 and OW-15. The purpose of the pre-pump tests was to make sure that drawdown could be measured in the surrounding 2-inch observation wells at the allowed pumping rate. Wells OW-12 and OW-15 were pumped for approximately 2-3 hours each using a submersible pump. Water levels were measured in the 2-inch observation wells. All observation wells (with the exception of the water table piezometer P-4) showed drawdown.

On August 29-30, 1984 a pump test was conducted on OW-12. For this test, Stevens Type F water-level recorders were set up on three of the 2-inch diameter observation wells; P-11, P-9, and P-5. Water levels in the remainder of the wells and the pumping well were measured by using electronic probes and steel tapes.

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TABLE 3 - Pumping Tests - Frequency of Readings

Elapsed Time (minutes)	Frequency of Measurements
0 - 5	Every 30 seconds
5 - 10	Every minute
10 - 30	Every 2 minutes
30 - 60	Every 5 minutes
60 - 120	Every 10 minutes
120 - 180	Every 20 minutes
180 - 360	Every 30 minutes
360	Every hour

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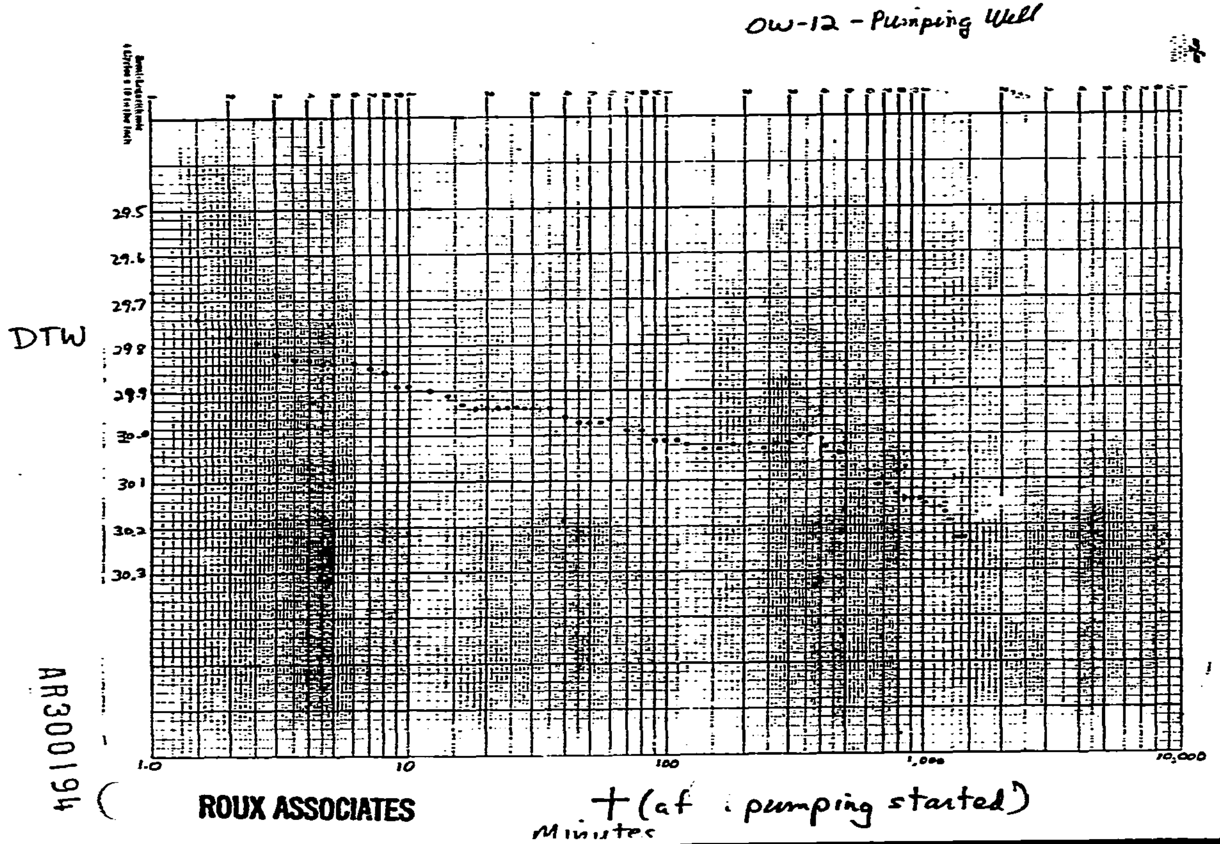
Figure 4 Graphical Representation of Depth to Water (DTW) to Time (Field copy)



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ROUX ASSOCIATES
50 NORTH NEW YORK AVENUE
PO BOX 268, HUNTINGTON, NEW YORK 11743

Table 4

PUMPING TEST FORM

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PROJECT Del. City, Del WELL OW-12 LOCATION 150' east of Rt 13 in [illegible] yard PAGE 1 OF 2

DATE 5-29-82 M.P. [illegible] HT. ABOVE G.S. 2.8' W.L. MEAS. W/ M-Scope
M.P. ELEV. 69.37 msl MEAS. BY SJS

r 2" PUMPING WELL OW-12 Q 12.3 ORIFICE ____ WEATHER cloudy - Cool
SCREEN 16.57 to 6.57 msl

✓ DRAWDOWN __ RECOVERY __ LOCATION SKETCH

TEST START 10:02 AM
END ____

TIME	minutes t	HELD	WET	D.T.W.	s			MANOMETER	Q	WATER TEMP.	REMARKS
[illegible]	0			27.32	0						
	:30		30-.50	29.50	2.18				10.5	58°	
	1:02		30-.32	29.68	2.36						
	1:39		30-.26	29.74	2.42						
	2:06		30-.22	29.78	2.46						
	2:32		30-.21	29.79	2.47						
	3:04		30-.18	29.82	2.50						
	3:32		30-.17	29.83	2.51						
	4:02		30-.17	29.83	2.51						
	4:33		30-.16	29.84	2.52						
	5:03		30-.16	29.84	2.52						
	6:01		30-.16	29.84	2.52						
	7:00		30-.15	29.85	2.53						
	8:00		30-.14	29.86	2.54						
	9:01		30-.11	29.89	2.57						
	10:00		30-.11	29.89	2.57				10.5	59°	
	12:00		30-.10	29.90	2.58						
	14:05		30-.09	29.91	2.59				10.5	58°	
	16:02		30-.07	29.93	2.61						
	[illegible]		30-.06	29.94	2.62						
	20:01		30-.06	29.94	2.62						
	22:02		30-.06	29.94	2.62						
	24:00		30-.06	29.94	2.62				10.5	58°	
	26:01		30-.06	29.94	2.62						
	28:01		30-.06	29.94	2.62						
	30:01		30-.06	29.94	2.62						
	35:01		30-.06	29.94	2.62				10.5	58°	
	40:04		30-.04	29.96	2.64						
	45:00		30-.03	29.97	2.65						
	50:00		30-.03	29.97	2.65						
	55:00		30-.03	29.97	2.65				10.5	58°	
	60:01		30-.04	29.96	2.64				10.5	58°	
	70:04		30-.01	29.99	2.67						
	80:0[illegible]		30-.01	29.99	2.67				10.5	58°	
	90:05			30.01	2.69				10.5	57°	
	100:01			30.01	2.69				10.5	58°	
	110:02			30.01	2.69						
	1[illegible]:04			30.02	2.70				10.5	57°	

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Table 1 (cont) PUMPING TEST FORM

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PROJECT [illegible] WELL OW-12 LOCATION [illegible] (Red) PAGE [illegible] OF

DATE 8-29-84 M.P. ____ M.P. ELEV. ____ HT. ABOVE G.S. ____ W.L. MEAS. W/ ____ MEAS. BY ____

r [illegible] PUMPING WELL SCREEN ____ Q ____ ORIFICE ____ WEATHER ____

TEST START ____ END ____

__ DRAWDOWN __ RECOVERY __ LOCATION SKETCH

TIME	t	HELD	WET	D.T.W.	s			MANO-METER	Q	WATER TEMP.	REMARKS
	[illegible]			30.03	2.71				10.75	57°	
	[illegible]			30.03	2.71				10.75	56°	
	180:01			30.02	2.70				10.5	57°	
	210:00			30.02	2.70				10.5	57°	
	240:00			30.03	2.71				10.7	56°	
	270:08			30.02	2.70				10.8	56°	
	300:01			30.02	2.70				10.8	57°	
	330:02			30.00	2.68				10.8	56°	
	360:00			30.00	2.68				11.2	58°	
	420:02			30.03	2.71				10.7	56°	
	[illegible]			30.04	2.72				10.8	56°	
	540.30			30.07	2.75				10.3	56°	
	601.21			30.08	2.76				10.2	57°	[illegible]
	661.50			30.11	2.79				10.5	57°	[illegible]
	684.22			29.98	2.66				10.1	57°	
	720.51			[illegible]	2.79				10.8	57°	
	[illegible]			[illegible]	2.81				10.2	56°	
	[illegible]			[illegible]	2.82				10.0	56°	
	[illegible]			30.14	2.82				10.1	55°	
	[illegible]			30.14	2.82				10.1	55°	
	[illegible]			30.15	2.83				10.1	56°	
	[illegible]			30.16	2.84				10.5	56°	
	1142.10			30.16	2.84				10.5	56°	
	1202.21			30.17	2.85				10.5	55°	
	[illegible]			30.19	2.87				11.25	56°	
				30.23	2.91				11.25	56°	
	[illegible]			[illegible]	2.91				10.5	56°	
	[illegible]			[illegible]	2.91				10.5	56°	
	1500			30.24	2.92				10.6	56°	
	1562			30.20	2.88				10.7	56°	
	1620			30.20	2.88				10.3	57°	
	1688			30.17	2.85				10.6	57°	
	1740			30.16	2.84				10.2	57°	
	1800			30.16	2.84				10.6	57°	
	[illegible]			30.17	2.85				10.3	56°	

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A discharge pit was dug by a backhoe approximately midway between OW-12 and OW-15 (Figure 3). This pit was dug to accomodate the discharge from these two wells during the course of the pump test.

During the course of the pump test, water levels were measured in wells on a regular basis (Table 3) and the recorders were ticked and the time written directly on the chart. Water levels were also taken in OW-15 during the test as this well used as a background well. A rain gauge was set up on-site to measure any precipitation during the tests. However, no rainfall occurred.

Prior to the pump test, water levels were taken for several days in OW-12, the surrounding observation wells, and OW-15 and these levels used for pre-pump test data.

The discharge rate was measured frequently during the test and was constant at 10.3 gpm. The temperature of the discharge was also recorded. All data was put on pump test forms and plotted on graph paper in the field (see Figure 4 and Table 4). The test was shut down after 33 hours because sufficient data to analyze and interpret were collected. At the completion of the pump test a 100 minute recovery test was conducted.

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On September 5-6, 1984 a 24 hour pump test was conducted on OW-15 using the same protocols as OW-12. Stevens water-level recorders were set up on P-7 and P-6 for this test. OW-12 was used as the background well during the course of the test. The discharge rate for this test was found to be 12.8 pgm. At the completion of the test a 100 minute recovery test was performed.

OW-7 was pump tested on August 21, 1984 using a submersible pump. Before starting the pump, pre-test water levels were measured in OW-7 with the pump in the well and also in the surrounding 2 inch observation wells. During the course of the pump test, water levels were taken regularly in the observation wells and the pumping well. This data was recorded on pump test forms and plotted on graph paper in the field. The rate of discharge was checked regularly and remained constant at 12 gpm throughout the test. At the end of the pump test (t = 8.5 hours) the recovery of water levels were measured for 100 minutes.

1.7 Additional Work

The following additional investigative work not included as part of work outlined in Attachment B of the Administrative Order of Consent will be conducted.

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A test pit investigation will be performed in the former PVC resin storage pit as identified in Attachment A of the Administrative Order of Consent. The purpose of this investigation is to determine if any residues of EDC or VCM remain in this area. The test pits will be excavated by a conventional rubber-tired backhoe to four feet into natural deposits or a maximum depth of eight feet. A geologist will visually inspect and log test pits in this area and collect selected soil samples for EDC/VCM analysis. It is envisioned that ten test pits will be excavated.

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2.0 REMEDIAL RESPONSE OBJECTIVES AND CRITERIA FOR EVALUATION OF ALTERNATIVES

The general objective of this remedial response is to effectively mitigate or eliminate damage to, and provide adequate protection of public health, welfare, and the environment from the ground-water contamination that has been identified and discussed in the report on Hydrogeology and Ground-Water Conditions at the Delaware City Site submitted by Roux Associates, Inc., February 4, 1983.

2.1 Objectives and Site Specific Goals

Specific objectives have been developed for this Site which are consistent with the general remedial response objective. These site specific objectives are divided into two categories: source abatement and mitigation of the existing plume of contaminated ground water.

A) Source Abatement

Development of cost-effective method(s) for eliminating the continued release of EDC, VCM and TCE to the ground water from the sources identified in the Administrative Order of Consent dated May 23, 1984.

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B) Mitigation of Existing Plume of Contaminated Ground Water

1) Development of a cost-effective method(s) for eliminating the potential direct exposure via human consumption for those receptors which have previously been identified as being impacted or have the potential to be impacted by the existing ground-water plume.

2) Development of a cost-effective method(s) to ensure natural or artificial containment and/or cleansing of the existing ground-water plume.

2.2 Evaluation of Criteria

In an effort to establish a means of evaluating the effectiveness of developed remedial alternatives, Section 300.68(h) of the National Contingency Plan (NCP) was reviewed. In accordance with the NCP, the following criteria were selected and weighed in order of importance to evaluate the effectiveness of the developed alternatives:

(1) Long term reliability

(2) Implementability

(3) Long and short term environmental impacts

(4) Operation and maintenance requirements

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(5) Public acceptance

(6) Time to implement

(7) Worker/community safety

The remedial alternatives will be ranked using the matrix approach as described in Chapter 3 of the EPA Final Draft Guidance Document for the Preparation of Feasibility Studies dated November 15, 1983 (Attachment I) with the criteria described above. Weighting factors which reflect the relative importance of the aforementioned criteria will be assigned. The various technologies which comprise each alternative will be evaluated individually; after which an overall rating will be determined for each alternative.

Cost estimates will be prepared for the top three remedial alternatives in each area (source abatement and ground-water plume mitigation).

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3.0 INITIAL SCREENING OF GENERAL REMEDIAL OPTIONS

In accordance with the remedial objectives, two major categories will be pursued in the development of a general approach toward remedial action: source abatement and ground-water plume abatement.

3.1 Source Abatement

The report by Roux Associates on the hydrogeology and ground-water conditions at the Delaware City Site indicated that the source(s) of EDC, VCM and TCE contamination is located within the existing plant site. Further investigation revealed five sources of EDC, VCM, and TCE. These sources have been identified in the Administrative Order of Consent: off grade batch pit, aeration lagoons, storm water reservoir, buried sludge pits, and former PVC resin storage pit.

A site inspection was conducted by Malcolm Pirnie (August 16, 1984) in which the identified sources were inspected. Past and present operating practices were reviewed with Stauffer and Formosa personnel. Past and present disposal practices are summarized by source as follows:

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Off-Grade Batch Pit: An unlined earthen lagoon receives wastewater from the S-1 and S-2 production areas when the wastewater sumps in these areas overflow. Solids are deposited in this lagoon which must be periodically dug out and disposed.

Aeration Lagoons: Two aeration lagoons with concrete bottoms and gunite sides receive process wastewater for treatment. Solids build up in these lagoons which must be periodically excavated.

Storm Water Reservoir: The Storm Water Reservoir is used for stormwater collection and occasionally receives wastewater from the E-2 production area when the wastewater sump overflows.

Buried Sludge Pits: Unlined pits were used to dispose of solid off-grade PVC resin material and cleanouts of sludge from the earthen lagoon. The pits have now been capped with a PVC cover designed to prevent percolation of rainwater.

Former PVC Resin Storage Pit: A former PVC resin storage pit has been emptied and backfilled. This area will be further investigated to determine if residual EDC/VCM remains. This work will be accomplished during the week of October 22.

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Potential remedial options were discussed with Stauffer and Formosa personnel during the investigation. The remedial options have been divided into four general categories. These general options are described as follows:

1. No Action: Current plant operations would continue. No modification would be made to existing sources of contamination.

2. Modification of Plant Operations: This general option involves assessing how current plant operations may be modified to limit the discharge of contaminants to the ground water. One such modification is the reduction of EDC usage as a cleaning solvent within the plant. Currently the plant is looking to eliminate EDC usage by year end 1984. Other modifications include preventing spillage of both raw material and product and preventing the overflow of process waste sumps.

3. Modification of Source Structures: This general option involves evaluating how the sources of contamination may be modified to limit further emission of material. Such modifications include lining the existing lagoons provided that a suitable

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liner material can be found. Also included would be diking the product handling areas and wastewater sumps to capture spills and overflows. Primary clarification may be implemented prior to aeration to centralize solids handling.

4. Removal of Sources: This general option involves evaluating the effectiveness of removing existing sources of contamination such as the buried sludge pits.

5. Use of Containment Structures: This option involves evaluation of isolating and/or capping existing sources of contamination. Feasible technologies that fall under each remedial alternative will be identified and screened.

3.2 Evaluation of Remedial Alternatives - Ground-Water Plume

The purpose of the remedial alternative evaluation is to use site specific data to identify any conditions which may limit or enhance the use of specific remedial technologies. The feasible remedial technologies that are being screened include ground-water controls and

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plume management. The following remedial alternatives are being evaluated in detail.

Ground-Water Withdrawal

The pump test data when interpreted will help evaluate the feasibility of an interceptor well system. The aquifer coefficients will enable an assessment of the number, spacing and pumping rates of any wells that would comprise such a system.

Ground-Water Treatment

Ground-water treatment may be required as part of any plume containment option, depending upon the ultimate disposal of the withdrawn ground water. Feasible treatment technologies that will be screened include biological, chemical and physical treatment, treatment within the existing on-site wastewater treatment facility and treatment at a publicly owned treatment works (POTW).

Formosa Plastics Corporation, Delaware may be able to utilize withdrawn ground water for their process water. This will be evaluated.

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Ground-Water Plume Management

The feasibility of plume management will also be evaluated. The following information will be obtained and synthesized into this evaluation:

(a) An identification of all water supply wells in the area and determination which may be threatened by the plume if no interceptor well system is employed.

(b) A determination of the availability and costs of providing alternative water supplies.

(c) A determination of probable future uses of lands above the plume and in the path of the plume, and the estimation of the probable effects the presence of the plume will have on these uses.

(d) A determination of the potential discharge rates of EDC/VCM in ground water into surface-water bodies and calculations of dilution ratios and the classification of these bodies.

(e) A determination of if, and how many more monitoring wells will be needed beyond present plume boundaries to evaluate long term migration of the plume.

(f) An evaluation of the possibility of migration of EDC/VCM through the underlying aquitard.

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Other Options Considered but Eliminated from Further Evaluation

No Action - Ground Water - This alternative has been evaluated and, is not considered feasible. Alternative water sources have already been supplied to impacted domestic well users.

- In-situ Permeable Treatment Beds to Treat all Ground Water. The installation of activated carbon treatment beds may not be effective in removing EDC and VCM. The lateral extent of EDC/VCM and the greater saturated thickness near Route 13 would make the installation and maintenance of treatment beds difficult and costly.

In-situ Treatment of Ground Water. This technology has been less used than other methods at sites so its reliability factor is uncertain.

Complete Plume Containment by Slurry Wall: This alternative would involve the installation of a slurry wall to contain the plume. However, the area of the plume is large and isolating the plume would eliminate a significant portion of ground water in the Columbia aquifer from future use.

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ATTACHMENT

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Final Draft

GUIDANCE ON
THE PREPARATION OF FEASIBILITY STUDIES

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November 15, 1983

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CHAPTER 3

TECHNICAL EVALUATION

One of the first concerns of the detailed analysis of alternatives identified in the screening process is the determination that suggested technologies are technically appropriate given specific site conditions. Section 300.68(i) of the NCP requires the following:

"(i) Detailed Analysis of Alternatives

(1) A more detailed evaluation will be conducted of the limited number of alternatives that remain after the initial screening...

(2) The detailed analysis of each alternative should include:

(A) Refinement and specification of alternatives in detail, with emphasis on the use of established technology;

.

(C) Evaluation in terms of engineering implementation, or constructability;

.

(E) An analysis of ... methods for mitigating [adverse environmental] impacts...."

Each remedial alternative is to be evaluated and rated relative to one another with respect to performance, reliability, implementability and safety considerations. The D&S Manual, the Corps of Engineers Engineer Manual "Preliminary Guidelines for Selection and Design of Remedial Systems for Uncontrolled Hazardous Waste Sites" (EC 1110-2-600), and the EPA publication "Handbook for Remedial Action at Waste Disposal Sites" (EPA-625/6-82-006) provide information and additional references which will aid the user in performing these detailed analyses of alternatives. The results of these evaluations provide the relative technical feasibility of remedial alternatives that are included in the cost-effectiveness summary evaluation.

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Elements of technical feasibility are discussed below in sections 3.1 to 3.4 and a suggested format for summarizing these evaluations is presented in section 3.5.

3.1 PERFORMANCE

There are two aspects of remedial actions that determine the desirability on the basis of performance, these are: effectiveness and useful life. The effectiveness of an alternative is the degree to which it will accomplish its design objective. The useful life is the length of time that the design level of effectiveness can be maintained.

3.1.1 Effectiveness

The NCP distinguishes source-control activities from off-site activities and the design objectives of remedial activities are generally developed in these terms. Proposed remedial technologies should be evaluated in terms of the ability to perform intended functions such as containment, diversion, removal, destruction, or treatment. Any special site or waste condition characteristics which affect performance should be considered and the design tailored to accommodate those conditions. The evaluation also needs to consider how effectively the component technologies can be integrated to provide an overall effective alternative. Where possible, design specifications should be developed in order to ensure effective performance. These specifications should recommend, where applicable, ASTM, AASHO, or other appropriate engineering standards. Of course, standards are not available for all applications at hazardous waste sites; in these instances performance specifications based on best engineering judgement must be developed.

3.1.2 Useful Life

Most remedial engineering technologies, with perhaps the exception of removal or destruction, deteriorate. For some technologies, the eventual deterioration can be somewhat ameliorated through proper operations and maintenance. However, eventually the technology may require replacement. In other instances no maintenance is possible and replacement is required after a certain length of time. Each alternative remedial action should be evaluated

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in terms of the projected service lives of the technologies of which it is comprised. Of course, this aspect of the cost-effectiveness analysis is also seen in the cost analysis in terms of the costs of operation and maintenance. However, the effects of the useful life of the project cannot be totally evaluated in terms of operation and maintenance costs. Resource availability in the future, reliability of the technology (which will be discussed below) as well as the appropriateness of the technologies, are also aspects of the alternative that are considered and indicated by an analysis of the service lives of the technologies and the useful life of the project.

3.2 RELIABILITY

Remedial alternatives generally represent not only the investment of considerable resources but also the methods by which public health and the environment are protected from threats due to hazardous substances. The reliability of such measures is a matter of great importance. Two aspects of remedial technologies that provide information regarding reliability are the operation and maintenance (O&M) requirements and the demonstrated reliability of the technology at sites of similar characteristics.

3.2.1 Operation and Maintenance Requirements

Evaluation of the O&M requirements of remedial alternatives should consider the resources required for effective and reliable performance. Such an evaluation emphasizes labor and materials in terms of their availability rather than strictly in terms of costs. The cost component of O&M evaluations is discussed in Chapter 7. Also, the frequency of necessary O&M operations and their complexity should be considered in the evaluation of alternatives. Technologies requiring frequent and/or complex O&M activities should be regarded as less reliable than technologies requiring little and/or straightforward O&M activities.

3.2.2 Demonstrated Performance

The user should give preference to technologies that have been proven to be effective under waste and site conditions similar to those anticipated during implementation. In some instances bench scale and pilot plant studies

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will be necessary to determine actual performance characteristics. These bench and pilot scale studies will, in general, be included as part of the remedial investigation. The technical analysis of remedial alternatives should not be based upon presumed performance of untested methods.

As more experience is gained in the application and development of remedial technologies, a broader spectrum of activities will have demonstrated performance. Now, however, many technologies are still in the research and development stages. If such technologies are included in suggested remedial alternatives the user should be certain to include information from authorities developing the technology supporting its use and giving an evaluation as to its expected reliability.

3.3. IMPLEMENTABILITY

Important aspects of remedial alternatives also to be evaluated are implementability, that is the relative ease of installation, and the times required to effect a given level of response. The ease of installation is generally known as constructability and is determined by conditions both internal and external to the site. The time requirements can be generally classified as the time to implement a given technology and the time required before results are actually realized.

3.3.1 Constructability

The constructability of any remedial alternative is determined by conditions imposed by the physical characteristics of the site and by conditions imposed by factors external to those of the site. Each remedial technology should be evaluated on the basis of these two fundamental factors.

3.3.1.1 Site Conditions

The evaluation of the constructability of remedial technologies with respect to site-specific conditions is fundamental to the technical analysis of alternatives. Thought of in its simplest terms, constructability with respect to site conditions is an evaluation of the ability to actually build, construct, or implace the remedial technology under consideration. This concept should not be confused with effectiveness.

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3.3.1.2 Conditions External to the Site

Conditions external to the site that affect the implementability of remedial technologies include the ability to obtain any necessary permits and/or access to the site as they are governed by federal, state, and local rules and regulations, the availability and acceptability of off-site disposal sites, and equipment availability for construction activities.

Certain types of remedial activities may require zoning clearances and local permits in addition to compliance with applicable State and federal regulations. Chapter 5 discusses some of these statutes in more detail. In addition, the acceptability of the proposed remedial action to the community can be of fundamental importance in determining the implementability of the action. The user should consider these, and any other special circumstances that affect the proposed alternative, in evaluating the implementability of the action.

3.3.2 Time

The time element of remedial efforts is an important aspect of site remedial planning. Emphasis should be placed on quickly eliminating exposure to hazardous substances. In this respect two measures of time that should be addressed are the time to implement a remedy and the time it takes to actually see beneficial effects of the implemented remedy.

3.3.2.1 Time to Implement

Implementation time includes the time it takes for special studies, design, construction and any other technical factors which may be required for the actual implementation of the alternative. Implementation time estimates should consider the effect of weather conditions, unanticipated site conditions, and safety precautions on the schedule. The user should evaluate the alternative in terms of the most likely construction schedule. This analysis may be based on engineering judgement gained from experience at similar sites or on such standard engineering procedures as critical path analyses.

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3.3.2.2 Time to Achieve Beneficial Results

Few remedial alternatives achieve instantaneous results. Generally, considerable time is required from the end of construction until results are actually seen. During this period it is common that ancillary measures, such as the temporary provision of alternative potable water supplies or temporary relocation, are taken to mitigate the threat. The user should evaluate each alternative in terms of the time it takes to see beneficial results in the environment: that is, exclusive of any ancillary measures which are in place to provide temporary protection to human health or the environment. Beneficial results should be defined as the reduction in levels of contamination required for the protection of public health (see Chapter 4) or the environment (see Chapter 6).

3.4 SAFETY

Each remedial alternative should be evaluated with regard to safety. This evaluation should include threats to the safety of any nearby communities and environments as well as to the workers, during implementation of the alternative. Major risks to consider are fire, explosion and exposure to hazardous substances.

The joint EPA, OSHA and NIOSH guidelines, or the Corps of Engineers guidance, which have been prepared to ensure the health and safety of workers at uncontrolled hazardous waste sites, may be used to determine the risk to worker health and safety during implementation. Alternatives should be designed to minimize risk during construction and should be evaluated in terms of the extent to which the final design can ensure such safety.

3.5 SUMMARY OF TECHNICAL FEASIBILITY

Figure 3-1 will assist the user in evaluating the remedial alternatives based on performance, reliability, implementability and safety considerations. The various technologies which comprise each alternative will be evaluated individually; after which an overall rating will be determined for that alternative. The user should assess site conditions that would affect the constructability of any technology and determine design and/or siting criteria

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FIGURE 3.1 SUMMARY OF TECHNICAL FEASIBILITY EVALUATION

	RELIABILITY						IMPLEMENTABILITY	
	Effectiveness		Durability[a]					
			Effective Remedial Protection		O & M Requirements		Previous Implementation	
Technical Alternatives	Comment	Rating	Comment	Years	Comment	Rating	Comment	Rating
A. A-1								
A-2								
A-3								
A-4								
A-5								
Rem. Alternative Summary								
B. B-1								
B-2								
B-3								
Rem. Alternative Summary								
C. C-1								
C-2								
C-3								
C-4								
Rem. Alternative Summary								

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FIGURE 3.1 SUMMARY OF TECHNICAL FEASIBILITY EVALUATION (Continued)

IMPLEMENTABILITY

Technical Alternatives	Ease of Installation: Site Conditions – Comment	Ease of Installation: Site Conditions – Rating	Ease of Installation: External to Site – Comment	Ease of Installation: External to Site – Years	Time: To Implement – Comment	Time: To Implement – Rating	Monitoring Requirements: To See Desired Results – Comment	Monitoring Requirements: To See Desired Results – Rating
A. A-1								
A-2								
A-3								
A-4								
A-5								
Rem. Alternative Summary								
B. B-1								
B-2								
B-3								
Rem. Alternative Summary								
C. C-1								
C-2								
C-3								
C-4								
Rem. Alternative Summary								

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FIGURE 3.1 SUMMARY OF TECHNICAL FEASIBILITY EVALUATION (Continued)

Technical Alternatives	SAFETY CONSIDERATIONS							
	Threat During Implementation		Facilities		Environment		Effect of Failure	
	Comment	Rating	Comment	Rating	Comment	Rating	Comment	Rating
A. A-1								
A-2								
A-3								
A-4								
A-5								
Rem. Alternative Summary								
B. B-1								
B-2								
B-3								
Rem. Alternative Summary								
C. C-1								
C-2								
C-3								
C-4								
Rem. Alternative Summary								

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to achieve a favorable outlook for construction. The user should rank each alternative based on its component technologies. However, the user should explicitly determine these individual components of the overall cost-effectiveness analysis. Measures that aggregate many factors cannot be effectively used in distinguishing between alternatives having similar cost-effectiveness ratios. See Chapter 8 for further discussion of this concept.

On Figure 3-1 alternatives are listed in the left column. Each alternative is described in terms of its component technologies. These are indicated by A-1, A-2, and so on, of alternative "A" in the Table. For example, alternative "A" may consist of site capping, diversion ditches, a slurry wall, groundwater pumping, and treatment of the effluent. The user may choose to rank the alternatives and technologies in order of their relative desirability with respect to each criterion, or to rate each alternative and technology with respect to the absolute degree to which the alternative or technology effectively fulfills each criterion. If the relative evaluation method is chosen the highest number is generally the number of alternatives under consideration. If the absolute evaluation method is chosen the numerical values are generally ranges such as 1 to 10, 1 to 5 or -1, 0, +1, with the lowest number representing a "base line" alternative. Whichever is chosen, the user should provide a consistent numerical ranking with the highest number indicating the most desirable alternative or technology under each criterion.

The only exception to the above scoring is the criterion for time. The numerical value for time should be the number of months or years relevant to each technology or alternative. The overall time should be the sum of the time required for implementation and to achieve beneficial results. Note that the time to see beneficial results should not include implementation time.

In addition to the numerical descriptions of each alternative there is allowance for comments. The comments under each sub-heading should include any outstanding features which render the technology particularly desirable, or any limitations which may hinder its use for remedial action at the site.

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